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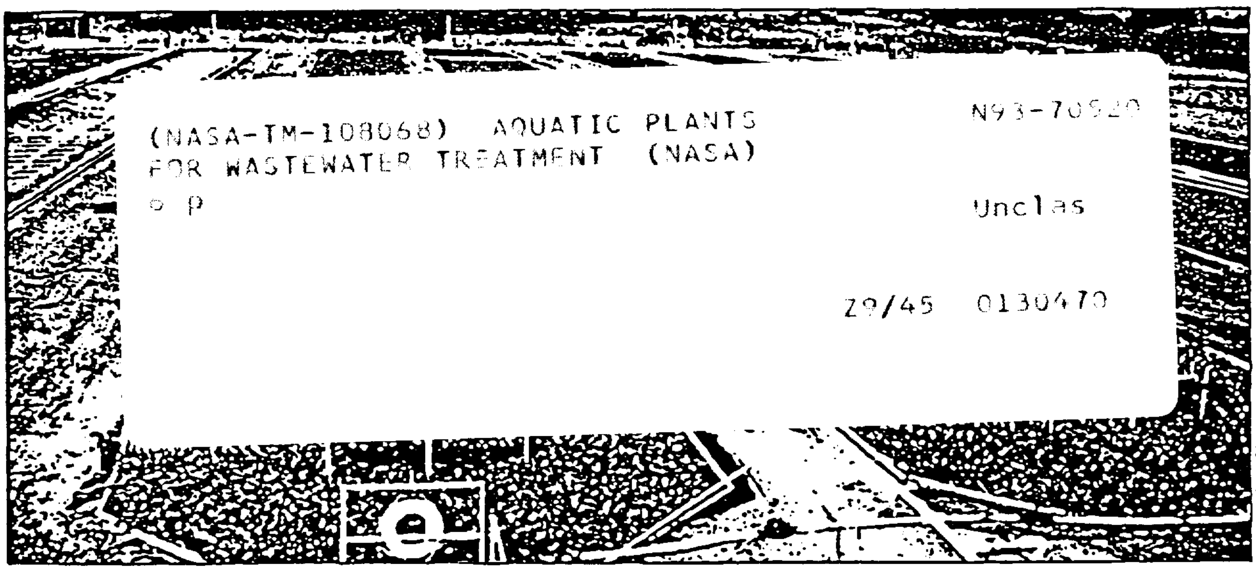
# AQUATIC PLANTS FOR WASTEWATER TREATMENT




COURTESY OF NASA

The ever-increasing demands placed on man's environment have prompted him to find economical and efficient ways to restore and preserve water and air resources.

B.C. WOLVERTON

We depend on earth's fragile ecological and atmospheric balance for our survival. Increased industrial development and population growth threaten this balance. Our limited supply of fresh water is being contaminated with human and industrial waste at an alarming rate, and our atmosphere is becoming polluted with the by-products of manufacturing.

Up to this point the most widely used wastewater treatments, such as trickling filters, have been mechanical. Such plants have proven to be too complex, costly, and energy-intensive, especially in small towns and rural areas in the United States and throughout developing countries. Wastewater treatment systems which are simple and require little or no maintenance must be developed to fulfill these needs.

It is becoming evident that aquatic plants have great potential for wastewater treatment and reclamation because their photosynthetic systems can revitalize the atmosphere and purify the water. As this technology has come to the forefront, many people are recognizing that aquatic plants have vast capabilities to restore the depleted resources of the earth.

The National Aeronautics and Space Administration (NASA) has emerged as a leader in developing this technology because of its research into closed ecological life-support systems for space travel and colonization. NASA's John C. Stennis Space Center in Mississippi supports the utilization of space technology to solve some immediate problems such as wastewater treatment and water reuse.

### The How and Why

The biological processes involved in using aquatic plants for wastewater treatment are very simple. The aquatic plant roots, bacteria, and other microorganisms play major roles in this process; each has its own function.

The plants are grown hydroponically (in the absence of soil) in a filter made of rocks that the wastewater flows through. Their roots, which are home to large numbers of bacteria and other microorganisms, extend into the wastewater. These microorganisms feed off the minerals and organic chemicals that pollute the wastewater. While digesting the pollutants, the microorganisms produce by-products such as sugars and amino acids, which are absorbed by the plant roots as food. The plants in turn supply oxygen and low levels of nutrients to the microorganisms for their rapid growth. This mutually beneficial, or symbiotic, relationship allows wastewater to be purified by the plant roots, and the plants' abundant new leaves help restore oxygen to the air and regulate the level of carbon dioxide and other atmospheric gases.

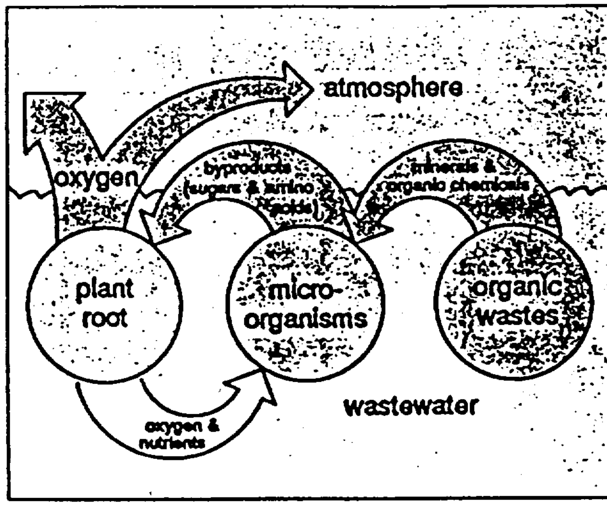
Using aquatic plants is thus an excellent solution for wastewater, and for nonindustrial sewage in particular. The large amount of harvested plant material resulting from this process is a potential source of energy, animal feed, fertilizer, and other valuable products.

The roots of most aquatic plants can remove low levels of toxic metals such as lead, cadmium, and mercury from wastewater. Radioactive elements that are sometimes present in wastewater can also be absorbed by the plants. When toxic chemicals removed from the water are concentrated in plant tissue, the harvested plants are disposed of safely.

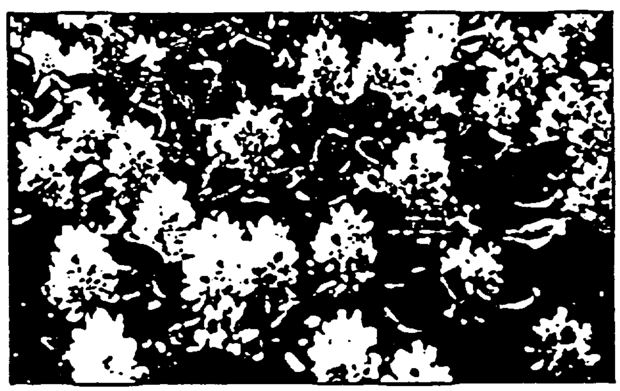
### The First Step

During the past 15 years, NASA has conducted studies at the Stennis Space Center using aquatic plants for treating both domestic sewage and industrial wastewater.

*Opposite:* After ten years of preparation, potable water was produced from this treatment plant, operated by the city of San Diego, using water hyacinths.



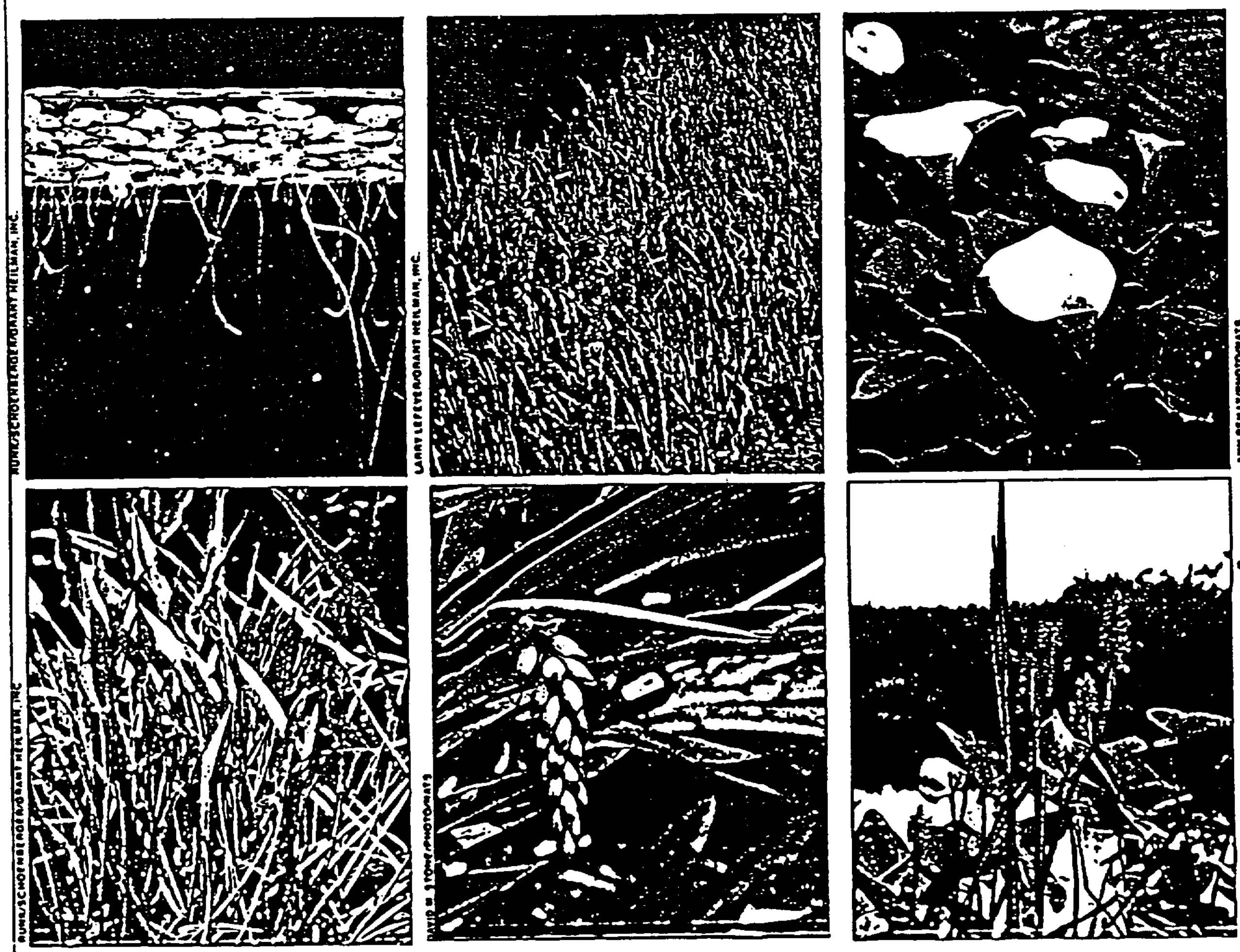

Artificial marsh wastewater treatment uses natural processes involving plants and microorganisms. Bacteria and protozoa digest organic wastes in the water, and wastes that the microbes excrete provide food for the plants. The plants transport oxygen from the leaves to the roots—an ability unique to aquatic plants. This oxygen is essential for the growth of the microbes. The plants also supply low levels of nutrients to the microorganisms.



The water hyacinth was the first plant that NASA studied for use in treating wastewater.

The first operational system developed by NASA used the water hyacinth, a highly prolific floating plant. In 1976 NASA began cultivating water hyacinths on the surface of sewage lagoons to improve the quality of wastewater.

The water hyacinths thrived in the wastewater while improving the water quality. Between 1976



Many plants have proven useful in removing organic wastes from water. *Top row:* Duckweed, cattails, calla lilies. *Bottom row:* arrowhead, ginger lilies, pickerelweed.

and 1987, the use of water hyacinths effectively treated the wastewater at the Stennis Space Center and saved millions of dollars in construction and energy costs.

In 1976 San Diego became interested in the NASA research. NASA participated in a technical advisory committee put together by the State of California and the City of San Diego to develop the water hyacinth technology for use in sewage treatment and water reuse. In June 1987, after approximately 10 years of study, the first potable water was produced from the water hyacinth Total Resource Recovery System in San Diego. Water from this experimental system is being evaluated through extensive epidemiology studies over a three-year period to compare the quality of recycled water with San Diego's present water supply.

### The Next Generation

Even though the floating water hyacinth is highly effective in properly designed wastewater treatment systems, its usefulness for year-round operation is limited to tropical and semitropical climates. In addition, the water hyacinth cannot be grown in salt water or brackish water, which further limits its usefulness in some industrial wastewater applications. Cold- and salt-tolerant plants such as bulrush, cattails, torpedo grass, and reeds—along with flowering plants such as canna lilies, arrowhead, and pickerelweed have been combined with rock filters to provide a more efficient and versatile aquatic plant wastewater treatment system.

Although microbial rock filters have been used to treat sewage for over 90 years and the ability of aquatic plants to enhance sewage treatment in natural marshes has been recognized for many years, the two processes have been combined into an artificial marsh only recently.

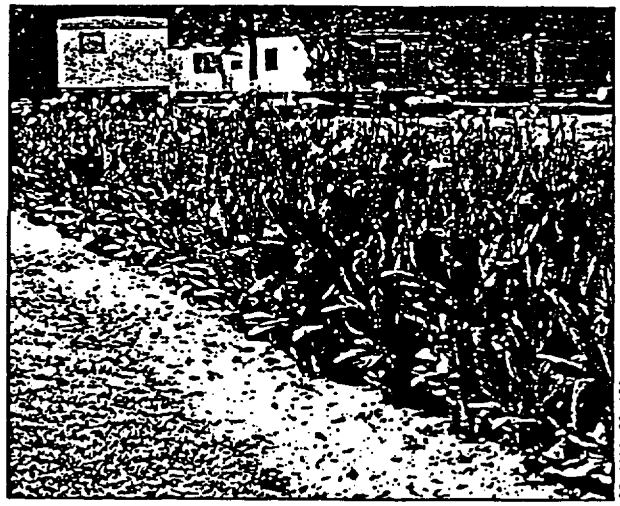
Long, shallow rock filters constructed so that the wastewater flows several inches below the rock surface are far more efficient than the systems containing floating water hyacinths. This system can accommodate the hardier cold- and salt-tolerant plants.

A large population of microorganisms is produced in this system because, in addition to the plant root zone, the rocks supply surface area for bacteria and other microorganisms to grow. Therefore, larger quantities of pollutants can be removed from the water.

## Who Can Benefit

The simplest form of the marsh filter system can be used with home septic tank systems. If the rock-plant marsh filter system is used to replace the leach field, septic tanks can be installed in most areas of the world. The odorous liquid from the septic tank is released underneath the rock filter and used as a hydroponic solution to grow ornamental plants such as canna, calla, and ginger lilies or other moisture-loving plants such as elephant ears. Once sufficient oxygen levels are achieved within the marsh filter, protozoa dwelling there remove odors and clear the water. These large microorganisms, which must have oxygen to live, feed on bacteria and other microscopic life. The purity of the water coming out of the filter is determined by the length and depth of the filter and by the length of time that the wastewater remains in the filter.

These systems can be used for schools, motels, hospitals, office complexes, mobile home parks, and so forth. A mobile home park in Pearlington, Mississippi, has installed such a system, creating a beautiful flower garden while reducing the cost of wastewater treatment. This system can treat up to 10,000 gallons of wastewater per day from 28 mobile homes.




A mobile home park in Pearlington, Mississippi, uses canna lilies to treat up to 10,000 gallons of wastewater per day.

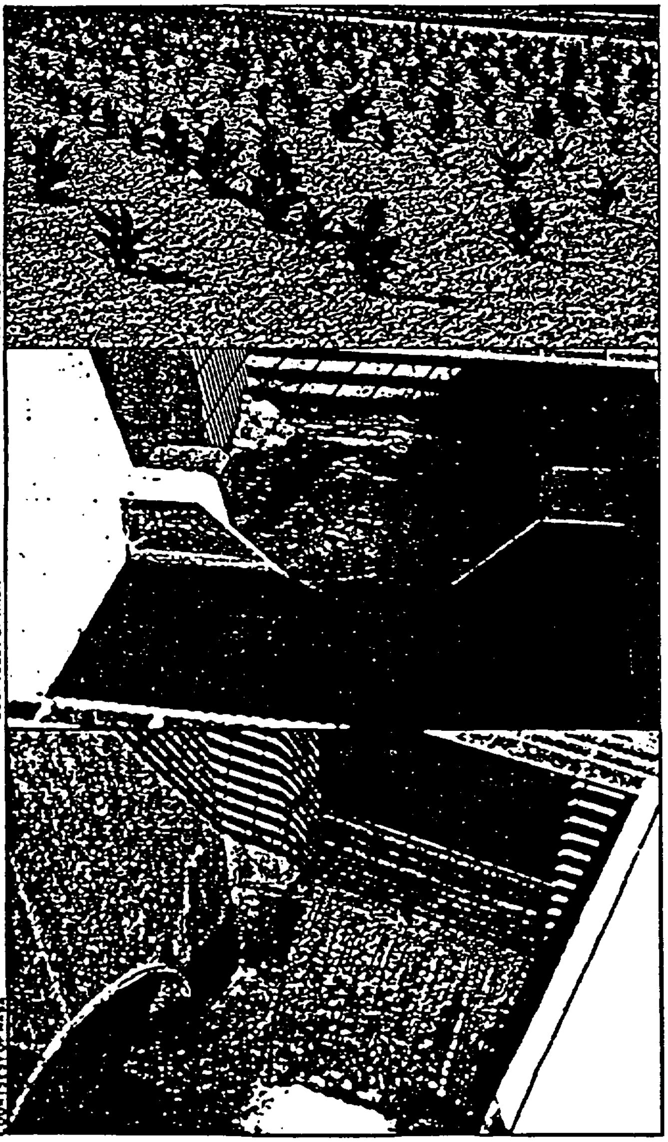
The town of Haughton in northeast Louisiana, with a population of 2,100, installed a slightly different treatment system using a lagoon combined with an aquatic plant marsh filter. This has resulted in an estimated cost saving of over 50 percent compared to conventional mechanical treatment.

Denham Springs, in southwest Louisiana, also has a lagoon/aquatic-plant treatment system, which treats wastewater from over 20,000 people. An estimated $1 million in the initial installation cost in addition to over $60,000 in annual operation and maintenance costs have been saved.

There are now more than 15 aquatic plant wastewater treatment systems in operation, under construction, or in the design phase in Louisiana. These systems range in size from 2,000 to 4,000,000 gallons per day, with flow-through times ranging from 24 to 48 hours.

Collins, Mississipi, is using rooted aquatic plants to clean wastewater in a system with no rocks. Shallow, open-channel marsh filters containing rooted southern bulrush and cold-tolerant, floating duckweed are being used to upgrade wastewater discharged from its sewage lagoon. This rock-free marsh system is achieving the required treatment levels even though the large amounts of duckweed produced during the summer months are not being harvested.

An economical means of harvesting the potentially valuable duckweed is being studied. Here again the



*Top:* This field of canna lilies treats the wastewater from more than 20,000 residents of Denham Springs, Louisiana. *Middle:* Water as it enters the field from a settling lagoon. *Bottom:* Clear water leaving the field.

abundant amounts of plant material produced by this system have good potential for use in agriculture. This small floating plant can be used for fertilizer or as an animal feed supplement. The protein and mineral composition of duckweed grown in domestic sewage is equivalent to soybean meal and is a potential substitute for this expensive ingredient in feed for chicken, catfish, and cattle.

The open-channel marsh filters have advantages as well as disadvantages. Because of the longer treatment time required for the open-channel marsh filter, a four to five times larger land area is required than for rock-marsh filters. However, the cost of importing rock to fill the rock-marsh filter is greater in some areas than the cost of the additional land. Risk of filter clogging is also greater in the rock filters.

The most recent aquatic plant wastewater treatment systems designed for Louisiana, Mississippi, and Alabama combine both open-channel and rock-filter technology into a single system requiring less rock. This combination also reduces the amount of algae from the sewage lagoon entering the rock filter, thus lessening the chance of filter clogging.

### Operation in Cold Climates

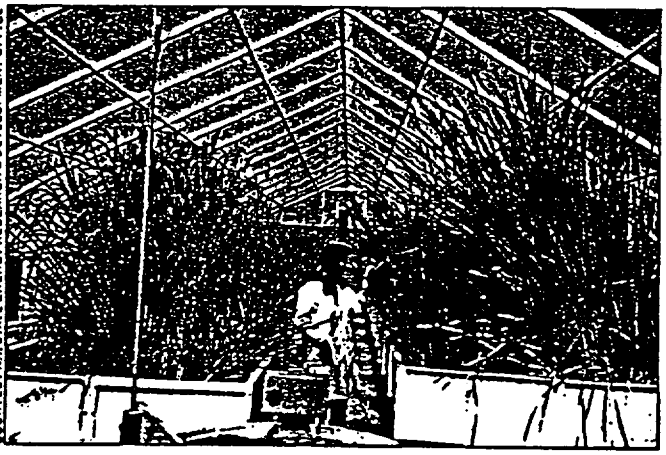
Studies conducted in Canada and Alaska have demonstrated that septic tank systems perform satisfactorily during the winter months in cold climates. Therefore, rock-marsh systems should perform well with cold-tolerant plants such as bulrush and cattails. The large amounts of heat provided to the underground septic tanks by residential wastewater should be sufficient to maintain biological activity in the aquatic plant root zone.

William Jewell, an agriculture engineer at Cornell University in Ithaca, New York, contends that greenhouse structures can maintain aquatic plant growth throughout the winter months in cold climates to enhance wastewater treatment. Cornell is currently studying the feasibility of installing greenhouse covers.

Future development of this technology for cold climates could include its integration into building designs. A wider variety of plants could be used to treat and recycle a building's wastewater, while the plant leaves could purify and revitalize the atmosphere, eliminating the "sick building syndrome" that develops in many energy-efficient buildings.

### How Much It Costs

The lagoon/aquatic-plant wastewater treatment system for Denham Springs, Louisiana, costs approximately one dollar per gallon of wastewater treated. A mechanical activated-sludge treatment plant (the conventional equivalent) would have cost over 20 percent more for the initial installation and



COURTESY N.Y. STATE ENERGY RESEARCH & DEVELOPMENT OFFICE

Researchers at Cornell University are testing the use of greenhouses to promote winter growth of plants used to treat wastewater.

50 to 60 percent more to operate and maintain.

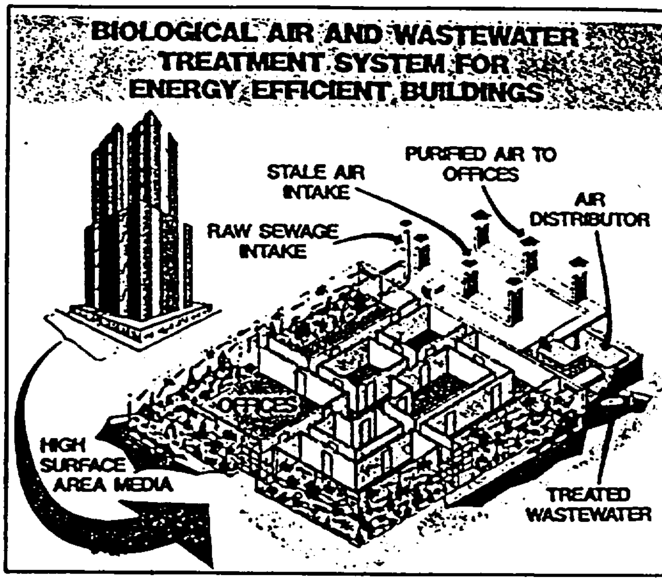
In general, aquatic plant treatment systems cost from 50 cents to one dollar per gallon to install in the southern United States. These costs vary with the level of treatment required and local land and rock costs.

When southern bulrush is used in the marsh filter, harvesting is required once every three to four years. Maintenance of canna lilies requires that the dead plant tops be removed each spring before new plant shoots appear. The cost of harvesting varies significantly depending upon methods used and manpower costs in the area. In some parts of Louisiana, fenced lagoon/marsh filter systems are harvested by controlled grazing, using animals such as goats.

## Conclusion

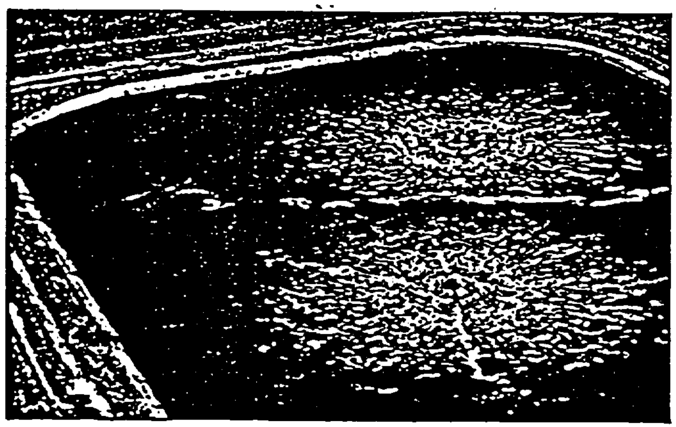
The use of aquatic plants in wastewater treatment is clearly the wave of the future. Already it is rapidly expanding, especially in the southern parts of the United States.

At present, the driving force behind installing these systems in small towns and rural areas is economic. They are generally less costly to install; in most cases they use few if any moving parts and consume little or no energy. In the future, they will no doubt produce energy and chemical raw materials. The exciting part of this technology is that we now have a promising and economical means of recycling domestic and industrial waste through a




COURTESY OF NASA

Aquatic plants could be an aesthetic, effective means of treating and recycling a building's wastewater while purifying its atmosphere.



CAMERON DAVIDSON/FOLIO, INC.

Conventional wastewater treatment as practiced in Arlington, Virginia. Such facilities can cost over $100 million to build and $10 million per year to operate. The use of aquatic plants is a less expensive alternative for water treatment in small cities and towns.

natural biological process that does not pollute the environment or consume vast amounts of valuable energy resources. In addition, it promises to provide an inexhaustible supply of raw materials for future generations while maintaining a clean, ecologically stable environment.■

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